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STELLAR LUMINOSITIES*

By HEBER D. CURTIS

THE *apparent* luminosities of the stars as we see them in the sky or observe them in a telescope are, as is well known, classified in a series of steps known as a magnitude scale, which has been conventionally so formed that a difference of five magnitudes indicates a difference in apparent brightness of just one-hundred-fold. To find the difference in brightness between any given star magnitude and the one next above or next below it, we must take the fifth root of one hundred, which is 2.512. A star of the sixth apparent magnitude is thus 2.51 times fainter than one of the fifth magnitude, 6.31 times fainter than one of the fourth, 15.85 times fainter than one of the third, 39.81 times fainter than one of the second, and just one hundred times fainter than a standard first magnitude star.

But these apparent magnitudes of the stars, useful as they are in certain fields of stellar statistics, are misleading and incorrect as a criterion of the actual relative luminosity of the stars. We know, for example, that there are numerous stars which, though actually giving out much more light than *Sirius*, appear faint to us because they are very much farther away than *Sirius*. Others, though giving out comparatively little light, appear moderately bright because they are close to us.

Could we put all the stars *at the same distance from us*, we

*From the *Publications of the Astronomical Society of the Pacific*, February, 1922, with the author's permission.

should be able to classify the stars with regard to their *actual*, rather than their *apparent*, luminosity. Such a process is, of course, not possible, but if we know how far away a star is from us we can easily find out what its brightness would be were it moved closer to us or farther away so as to be at some arbitrary fixed distance. By common consent among astronomers, this fixed distance has been set at 32.6 light-years[1] (corresponding to a parallax of 0″.1), and when we have determined how bright a star would be at this distance of 32.6 light-years, we have found what we may term its real relative luminosity, or *absolute magnitude*.

Once we know the parallax (and hence the distance) of a star, all that we need to determine its *absolute* magnitude is a knowledge of its *apparent* magnitude, and either of two very simple equations which involve only the use of arithmetic and a two-place logarithm table. These equations are:

Abs. Magn. = *App. Magn.* + 5 + 5 × (*logarithm of the parallax in seconds of arc*), *or*

Abs. Magn. = *App. Magn.* + 7.6 − 5 × (*logarithm of the distance in light-years*).

A few examples will serve to illustrate the use of these equations.

1. What is the absolute magnitude of a star of the eighth apparent magnitude, whose parallax is known to be 0″.045?

Log .045 = 8.65 − 10, or −1.35, and five times this = −6.75; whence

Abs. Magn. = 8 + 5 − 6.75 = +6.25.

2. If a star of the sixth apparent magnitude is as far away as 100 light-years, what must be its absolute magnitude?

5 × log 100 = 10, hence,

Abs. Magn. = 6 + 7.6 − 10 = +3.6.

3. If a star of the sixteenth apparent magnitude is known to be of the same brightness as our Sun (absolute magnitude + 5), how far away must it be? Here we have,

+5 = 16 + 7.6 − 5 × *log distance*.

5 × *log distance* = 18.6, or *log distance* = 3.72, whence,—

Distance = 3,500 light-years.

4. How bright would our Sun appear (absolute magnitude + 5), if it were moved away to a distance of 10,000 light-years?

+5 = *App. Magn.* + 7.6 − (5 × 4.0), and

Sun's apparent magnitude = 17.4.

[1]The light-year is nearly six trillion (6,000,000,000,000) miles.

It is now about eight years since Dr. Russell, by plotting the absolute magnitudes of the stars for which data were then available, showed the remarkable progression of absolute magnitude with spectral type, and the clear division of the redder stars into "giants" and "dwarfs." An amount of material is now available which is at least ten times greater as regards quantity and much better as to quality; it will accordingly not be without interest to collect in a single diagram all material at present available.

In a card catalog of all parallax results there are about 5,000 separate entries; many of these, however, are the older results or those secured by methods of inferior accuracy. We have at present (January, 1922) about 1,600 strictly modern photographically determined parallaxes; as there has been, wisely, considerable duplication, these are distributed among some 1,100 stars.

We have in addition the fine list of 1,646 absolute magnitudes determined by Adams and his associates. By the study of the relative intensities of certain sets of lines in stars of known distances, Dr. Adams concluded that the variations which he found could be used as criteria of the absolute magnitudes of the stars; this then is a method which gives us a parallax determined spectroscopically through the absolute magnitude. Though depending fundamentally on direct parallax results for its scale, it can be applied to stars which are difficult if not impossible to investigate by the direct photographic method of determining parallax. To the above material may be added the list of 556 hypothetical parallaxes of double stars determined by Jackson and Furner.

In pruning our list of directly determined parallaxes and selecting the results to be included there is manifestly abundant room for the exercise of the personal bias of the compiler, and doubtless no two workers in this field would agree precisely as to the material to be eliminated, or as to the method of combination and weighting to be adopted.

In preparing this plot of stellar absolute magnitudes (facing page 00) my effort has been to include only the most trustworthy material, and to leave the more uncertain points for the future to decide. The following principles have governed the

method of selection and combination; while in some respects the procedure may have been ultra-conservative, I am aware that it may savor of radicalism in others. I feel certain, however, that we may modify this procedure in any manner within reason, and still obtain a diagram of absolute magnitudes essentially the same as the one shown in this paper.

1. The spectrographic results of Adams, and the hypothetical parallaxes of Jackson and Furner, have been incorporated without change.

2. The direct parallaxes employed are almost without exception strictly modern photographic determinations, though a few heliometer results greater than 0″.050 have been included. No meridian circle parallaxes have been used, nor any values secured through "mass determinations" of parallax.

3. As our direct parallaxes are referred to fainter comparison stars, giving parallaxes relative to these comparison stars, to obtain absolute parallaxes we must increase the values found by the probable parallax of the comparison stars employed. To make this reduction from relative to absolute parallax, 0″.003 has been added to the Mount Wilson direct results, and 0″.007 to the results from all other observatories. The use of a smaller constant than this would make very little difference in the general appearance of the diagram.

4. No negative parallaxes have been used in any case in the formation of mean values, even when the addition of the reduction from relative to absolute would have given a small positive value.

5. To the sources mentioned above there have been added about fifty hypothetical parallaxes secured from members of moving clusters and other methods.

6. No systematic corrections, other than the reduction from relative to absolute mentioned above, have been applied, and all results, by whatever method, have been combined with unit weight.

7. No Cepheids have been included.

8. The spectral type generally follows the Henry Draper Catalog, or Adams when this is not available. Occasionally, in the more crowded portions of the diagram, it has been necessary to place the signs between the Draper and the Adams classifications.

The absolute magnitudes of 2,375 stars, determined in this manner, are shown in the plot, where the vertical coördinates are absolute magnitudes, and the horizontal are the spectral types from the blue B stars through types A, F, G (solar type stars), K, and the redder M type stars. The smaller circles represent the hypothetical results for double stars, the small dots the values secured from direct parallaxes while the larger circles indicate the spectrographic results of Adams. Where a direct parallax has been combined with a spectrographic or

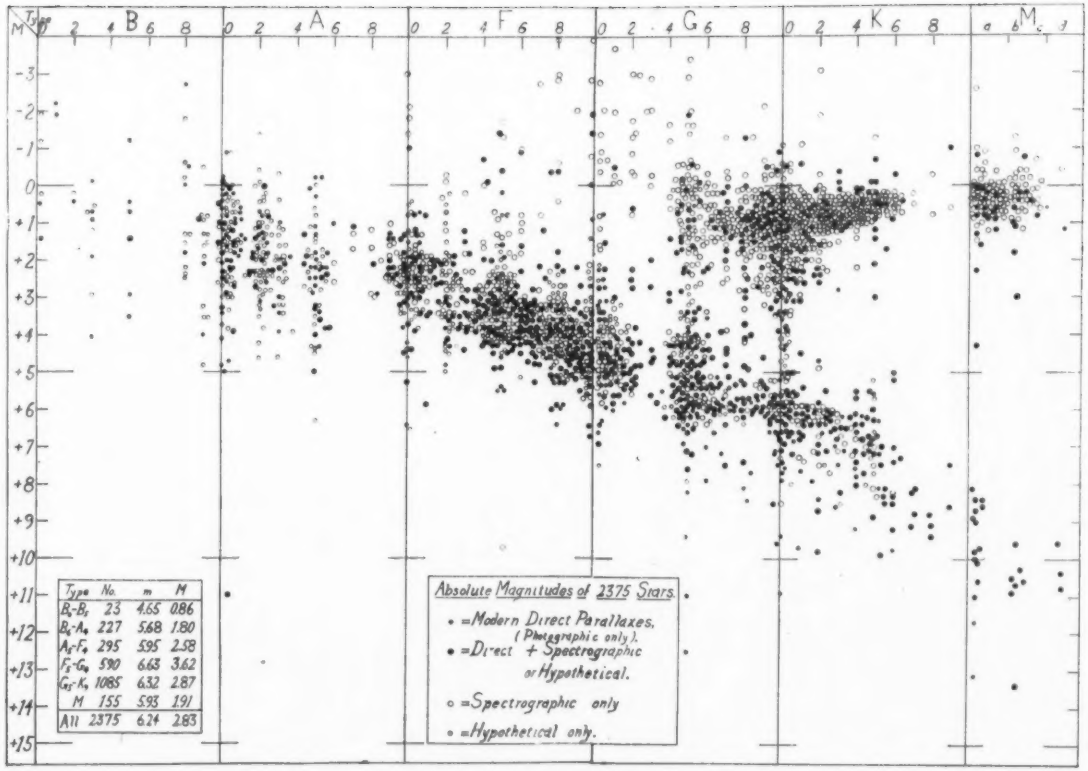
Absolute Magnitudes of 2375 Stars.
• =Modern Direct Parallaxes. (Photographic only).
• =Direct + Spectrographic or Hypothetical.
○ =Spectrographic only
○ =Hypothetical only.
Type No. m M
B5-B7 23 4.65 0.86
B8-A0 227 5.68 1.80
A1-F4 295 5.95 2.58
F5-G8 590 6.63 3.62
G9-K5 1085 6.32 2.87
M 155 5.93 1.91
All 2375 6.24 2.83

Diagram showing the relations between the absolute magnitudes and spectral types of 2375 stars

hypothetical value, or both, the resulting absolute magnitude is indicated by the larger solid dots; many of these, representing the mean of three or four modern photographic determinations plus a spectrographic or hypothetical value, may be regarded as very accurately known.

It will be seen at once from this diagram that Russell's progression of absolute magnitude with spectral type is indicated with remarkable clearness along the "dwarf" branch, and also the sharp division of the later spectral types into giants roughly forty times as bright as the Sun, and dwarfs from ten to one hundred times fainter than the Sun (our Sun is of absolute magnitude + 5 and spectral type about G6, an entirely representative member of its stellar class). The bifurcation into dwarfs and giants appears to start rather suddenly at about spectral type G5; before this point the evidence for such a division is none too certain.

From types A0 to about G3 the general "dispersion" in the values is, on the whole, astonishingly small, and some part of the small amount of scattering exhibited may be due to the inaccuracy of our results. With perfect values of the distances of these stars, it might well be that this portion of the diagram would be even more compact and regular than it is at present. As it is, within these spectral limits, if we can classify an unknown star accurately as to its spectral type, and know its apparent magnitude, we can assign its parallax from these facts alone through an inspection of the diagram about as accurately as we can determine it directly. For example, a star of visual magnitude 9.5, if known to be of spectral type F8, is almost certainly possessed of a parallax of $0''.008 \mp 0''.004$; the probabilities that this parallax of $0''.008$ is in error by more than the amount given are very remote, though there is, of course, the chance that we may be dealing with one of the relatively few giants of the type.

For a star of spectral type K0 the matter is not so simple, and will not be simple till we have more accurate knowledge as to the relative numbers of the giants and dwarfs of this type. The probabilities in this case are that a K0 star of visual magnitude 9.5 has a parallax of either $0''.002$ or $0''.025$. If, as most investigators hold, the dwarfs very greatly outnumber the

giants, the chances, favor the latter value, and the uncertainty can be removed by determining whether the spectrum is of giant or dwarf type.

The agreement between the values secured by the different methods is very close, on the whole. As the larger dots are used to indicate combinations of direct with the spectrographic or the hypothetical results, this procedure naturally has some effect in "smoothing out" the diagram, yet there remain sufficient individual results by the three methods to emphasize the essential agreement of the data which have been employed in plotting the absolute magnitudes of these 2,375 stars. The omission of all negative parallaxes in forming means, the use of only the larger heliometer values, and the employment of a reduction from relative to absolute parallax larger than has been the custom, all have a tendency to depress the plot in the direction of the fainter absolute magnitudes. But, as in the great majority of the cases just mentioned there exist values by other methods, this effect is believed to be very slight, and the essential agreement of the results by the different methods with one another and with the combination values supports this view.

One is particularly impressed by the agreement of the hypothetical results for double stars with the rest of the data, as one works through a card catalog of parallax results. These values, from the nature of the case, form the greater portion of the evidence in the types from B8 to F0, and are much fewer among the later spectral types. More interesting, perhaps, than the agreement of these hypothetical parallaxes with the data as a whole, is the confirmation of the hypothesis used in securing these values, namely, that the combined mass of the components of an average double star must be very closely twice the mass of the Sun. This is a further proof, if such were needed, of the essentially average character of our Sun among the stars in general.

From this diagram, also, it is not difficult to see why we get occasional negative parallaxes in the most refined modern work. The visual magnitude of the comparsion stars used in most modern direct determinations is from 9.0 to 9.5. From type A0 to G2 our diagram is *perhaps* fairly closely representative of these types; in the later types we feel certain that there are a

great number of dwarfs yet to be included. Reasoning from actually existing evidence as shown by the diagram we may then say that the probabilities rather favor a star of visual magnitude 9.5 having parallaxes as follows, according to its spectral type:

TYPE	PARALLAX
A5	″.003
F5	.006
G0	.010
K0	.020 (or .002)
K5	.030 (or .002)

The occurrence of even one later type dwarf in a group of three or four comparison stars would certainly make for a small or negative parallax in any distant star under investigation. The determination of the spectral types actually employed in a considerable number of representative fields would go far toward clearing up the question of the magnitude of the correction to reduce from relative to absolute parallax.

Such a diagram forms as well a concrete method of taking stock as to present progress and future needs in the determination of stellar distances. More direct parallaxes are urgently needed for stars of type A, and for stars of type B our knowledge, as far as direct parallax determinations are concerned, is practically zero. Does the slope of the progression in absolute magnitude as one goes toward the earlier types decrease somewhat, as seems slightly indicated for type A in the diagram, giving us B type stars averaging about + 1 in absolute magnitude, or does it rise without change so as to approach more nearly to absolute magnitude — 1 for the B stars? The stars of this type form perhaps the most urgent, as well as the most difficult, field for direct parallax determinations to-day, particularly as the spectrographic method cannot as yet be applied to them. So far as the very scanty evidence of the diagram is concerned, we should expect that a very considerable number of the 350 B type stars which are brighter than the fifth magnitude will prove to have parallaxes of the order of 0″.020. So confident do I feel of this that we are putting a number of early B type stars on the program at Allegheny, and the same thing is being done at the Leander McCormick Observatory. We may find numerous disappointments

in the way of negative parallaxes but even so, as a Hibernian might put it, negative results will be positive ones, in a sense.

As to the stars of types K and M, it would seem that our parallax programs are now really overloaded with faint stars of these types possessing large proper motions, exceptional objects through this method of selection; and a type of star of which our present knowledge seems reasonably complete, except as to the relative frequency of their occurrence. It would seem to be much more valuable at present to strive for some such aim as the determination of the distances of all stars which are so bright, and whose proper motions, spectral types, and radial velocities are in general so well known as the stars of Boss's *Preliminary General Catalogue*.

DARK STRUCTURES IN THE MILKY WAY (SECOND CONTRIBUTION) WITH CATALOGUE AND DESCRIPTION

By T. E. Espin

IN this Journal for July-August 1912 there was a paper of mine on "The Dark Structures in the Milky Way" in which it was suggested, among other things, that much of the peculiar phenomena might be explained by a "vast number of what are most like absorption vortex rings seen at all angles and consequently appearing as ellipses". Much attention has lately been given by various observers to the question of absorption, and Professor Barnard has published a list of these dark bodies. The following paper gives the result of a study which has for its foundation Professor Barnard's photographs of the Milky Way (*Lick Publications*, vol. XI). In addition I have had before me the photographs of the Milky Way published in the *Harvard Annals*, vol, 72, No. 3 and vol. 80, No. 4, also there have been most kindly placed at my disposal photographs with various exposures and lenses by: Mr. H. Ellis of Lyme Regis, Rev. W. Bidlake of Crewe, Mr. J. M. Offord of West Ealing, Mr. Lawrence Richardson of Newcastle-on-Tyne, Mr. F. W. Longbottom of Chester, Mr. Evens, Mr. Milburn's photographs taken with the little automatic stellar camera at this observatory,—to all of whom I desire to express my great indebtedness. Generally speaking the result has been to confirm and elaborate the conclusion arrived at in my former paper. It seems indeed probable that the curious curves, and chains of stars noted by many observers may best be explained by an absorption in their neighbourhood, which by blotting out, in a great measure, the stars in the background leaves a curve or line of stars. Again the brighter stars generally show signs of vast absorption in their neighbourhood, and the absorption takes the forms of either being ill-defined or with regular rings, generally

seen as ellipses. Almost universally star clusters and nebulae have these rings, and apparently the cluster is frequently displaced from the centre by perspective. In some cases these rings are broad on one side, and narrow at the other apparently from the nearness of the one, and the distance of the other. Sometimes in the case of groups of stars the absorption appears to be of a thin globular form, dark therefore at the edges, but leaving stars at the centre. In the case of the ellipses the major axis usually points in the direction of the Milky Way. In some cases two ellipses will intersect leaving a very dark space, or hole, of oval form with a major axis of a different position to that of the two ellipses according to the angle under which they meet. Then again some stars have what might be called absorption atmospheres. This was first noticed on a photograph taken by Mr. Milburn of α Aurigae and neighbourhood, and is equally well defined on a fine photograph by Mr. Richardson. With a larger lens this is lost in halation. Many other similar cases have been suspected which may, or may not, be due to some peculiarity in the lens or plate.

For convenience I have divided the various forms of absorption met with into the following rough classes:

1. Dark spots catalogued by Barnard and not included therefore in this paper.
2. Stars showing absorption closely round them.
3. Oval absorption where the background is more or less blotted out.
4. Clusters, Nebulae, groups of Stars, with absorption rings generally seen as ellipses.
5. Stars with absorption connected with them.
6. Stars with rings generally seen as ellipses round them.

This classification was only made for convenience, and not with the idea that the phenomena are really due to different causes.

Generally the procedure in the examination of the plates was as follows: The plate was held at sufficient distance from the eye to obliterate the fainter and minute details. The dark absorption is best seen thus. When once this has been detected the Harvard plates of the Milky Way were examined, and such other photographs as were available. The place and diameter were then

measured by a ruler and the position by a protractor, the top of the plate being considered as the true North except in the case of the Harvard plates where N. and S. are given. The description and peculiarities were next recorded.

As regards Class 3, of the two most marked examples one occurs in Cygnus north of β (No. 115) and the other No. 94 gives rise to the curious curve of stars, in which is M 11, which forms the north boundary of the little asterism of Scutum Sobieski, and with its extension is visible in the summer sky to the unassisted vision. Of Class 4, No. 134 may be considered as typical. In many cases the system is complex, and several rings may be traced as in the case of No. 73 which is best seen on pl. 55. In the case of a cluster, M 23, pl. 42, may be taken as a type. Of Classes 5, 6, β Cass., plate 89, is a good example.

Several possibilities are indicated which I put forward with all diffidence:

(1) The absorption round the brighter stars is often of great extent, and if it should indicate the limit of their systems, then stars will be found at considerable distances from them which in P.M., or in other ways, are distinctly related to them.

(2) In some cases the absorption spectrum of a star may be due wholly or in part, to the fact that the ring is in the line of sight, and if in process of time, either by the motion of the system, or by solar motion, this condition should no longer obtain, the spectrum would be modified and the colour of the star changed.

(3) Probably all stars, clusters and Nebulae are surrounded with a ring of absorption. Such ring is clearly seen in the case of certain Nebulae when the major axis is in the line of sight, and consequently the absorption ring is seen projected on the central mass in the form of a dark line (see *Pub. Lick Observatory*, Vol. XIII, Plate III).

(4) It seems doubtful whether the P.M. of stars in Classes 5 and 6 have any relation to the absorption around them. There are some cases, as for instance α Aurigae, β Cassiopeiae, α and β Geminorum, γ Cygni, where the P.M. is apparently nearly coincident with the major axis, and possibly α Aquilae and α Orionis.

(5) The class of spectrum does not seem to be immediately connected with the apparent amount of absorption.

(6) Though the results obtained in this paper refer to objects in the neighbourhood of the Milky Way, probably they are true of objects throughout the heavens, should it be feasible to secure photographs of them with sufficiently long exposures.

(7) The rings are many times greater in diameter than in thickness.

In the following catalogue the more remarkable examples of the various classes will be found. The list is by no means exhaustive, and further study of Barnard's photographs and those of others would yield many more. Col. 1 gives the current number; Col. 2 the number of Barnard's plate; Col. 3 the star, cluster or Nebula, etc.; Col. 4 the measure in inches of the place of the object on Barnard's plate, the objects on the Harvard plates being similarly treated; Col. 5 the position angle, roughly read by means of a protractor, of the major axis; Col. 6 the length of the major axis roughly measured in inches and tenths; Col. 7 the class as given above; Col. 8 additional facts, the following abbreviations to save space being used: *A* absorption, A_2 absorption round stars, *b* broad, *c* centre, *ci* circular, *cl* cluster, *d* dark space, *e* end, *ex* extended, *exc* excentric, *i* ill-defined, *irr* irregular, *H* Harvard Northern Milky Way, *h* Harvard Southern Milky Way, *l* little, *m* marked, *nci* nearly circular, *, or *cl*, *nc* nearly central, *nws* not well seen, *o* obliterated, *op* obliterated partly, *pf* partly filled in, *sm* small, *v* very, *ws* well seen, *p*, *n* ,*f*, *s*, preceeding, north, following, south. Numbers refer to plates where the object is also seen. Where the current number is marked with an asterisk, additional facts will be found in the notes at the end.

CATALOGUE

No.	B	Name	Position		P	D	Cl	Notes
			in.	in.	°	in.		
1	2	κ Cass.	R 2.8	B 3.6	190	0.5	6	$*n$, 89, another 0.2 in bn, $*_s$
2	2	β Cass	R 0.8	B 1.4	347	1.2	5,6	$*s$, 89, wm$s$
3	2	10 Cass.	R 1.0	T 2.4	152	0.9	5	$*s$
4	3	ν Andr.	L 3.7	T 3.9	2?8	0.8	5, 6	$*lsf$, 4, 102
5	5	α Cass.	R 2.4	B 1.5	25	1.2	5,6	$*ls$
6	5	N.G.C. 281	R 3.5	B 1.6	32	0.6	4	neb, sc

No.	B	Name	Position		P	D	Cl	Notes
			in.	in.	°	in.		
7*	5	γ Cass.	L 3.4	T 3.5	47	2.0	?	**spc*
8	5	δ Cass.	L 1.0	T 3.6	11	0.5	6	nws, 7
9	5	ϕ Cass.	L 1.4	B 2.8			?	A_2, cl, i, 7
10	6	ϵ Cass.	L 1.6	B 2.1	207	1.4	6	wm*n*, 7, H5
11	6	.....	L 1.2	B 2.6		0.3	3	A between 2*
12*	6	.....	L 1.3	T 1.4	126	2.2	6?	
13*	6	31 Cass.	R 2.2	T 1.4	252	0.7	5, 6*c	
14	6	N.G.C. 663	L 2.0	B 0.5	?		?	A*n*, 7, 8
15	9	N.G.C. 869	L 2.3	T 3.8	70	1.9	4	cl, *np*, Am*p* and *n*, H6
		" 884						
16	11	ι Persei	L 2.5	B 2.0	.....	0.4	2	*c, H6
17*	12	θ Persei	R 2.0	B 1.7	70	0.4	2	**p*, irr
18	18	N.G.C. 1647	L 1.3	T 2.4	330	1.2	?	cl, c, *n* m
19	19	ϵ Aurig.	R 3.1	T 1.4	133	1.5	5, 6*nc, l*p*, D, *f*	
20	19	N.G.C. 1664	R 1.8	T 1.5	217	0.9	5, 6cl, *sfe*	
21	19	η Aurig.	L 3.1	T 3.1	178	1.2	5, 6*nc	
22	19	ω Aurig.	R 2.8	B 2.1	107	0.4	5	di
23	21	32 Orion.	R 0.4	B 3.2	90	1.5	5, 6**sfc*, H9	
24	21	ω Orion.	R 1.8	B 2.0	57	1.1	5	**psc*, H9
25	21	λ Orion.	R.1.1	T 2.3	5	2.1	5, 6*nc, 1.2 in b	
26	22	N.G.C. 2168	R 2.8	T 3.9	249	1.1	4	nws, best *ps*
27	22	N.G.C. 2174	R 2.8	B 1.5	279	1.5	4	cl, nc, nws
28	22	μ Gemin.	L 2.3	B 2.8	272	0.5	5	
29	21	α Orion.	L 2.9	T 3.9	41	1.2	5	*nc, ex*n* and *sp*, irr, 24
30	21	*	L 2.7	T 2.6	315	0.4	2, 5irr, 24	
31	25	.....	L 1.5	B 1.4	294	0.7	6	irr, D, 24
32	25	N.G.C. 2174	R.2.8	T 0.5	254	0.9	4	cl, nc, ws*f*
33	26	N.G.C. 2245	L 3.5	T 0.6	180?	....	4	ws*n*, 28
34	26	N.G.C. 2237	L 3.3	T 3.7	180?	2.0	4?i, vD*s*, 28	
35	26	8 Monoc.	R 2.7	B 4.1	65	0.7	6	irr
36	26	15 Monoc.	L 1.9	T 0.6	180?	1.0	4	
37	28	13 Monoc.	R 1.8	B 2.0	108	0.7	6	ws, *sf*, 29
38	28	ξ Gem.	L 1.6	T 0.6	274	1.3	6	**sp*, 29, b 0.2 in *f*
39*	29	γ Gem.	R 2.8	T 1.8	257	1.3	5	
40*	28	.....	R 2.5	T 3.3	228	1.5		29
41	31	19 Monoc.	L 1.7	B 3.0	268	0.5	5, 6i, h1	
42*	32	α Gem.	L 3.0	B 3.5	255	2.2	5	**np*
43	32	β Gem.	L 1.4	B 1.0	256	1.3	6	nci
44	32	.....	L 2.2	T 0.6	232	0.9	3	A_2
45*	35	θ Librae	R 2.4	T 2.0	195	0.6	2	**sf*
46	35	ν Scorp.	L 2.4	B 3.9	32	1.5	6	**sp*, i, ws*p*
47	35	β Scorp.	L 3.4	B 3.7	153	1.6	6	**sf*
48	35	47 Librae	R 2.6	B 4.0		0.3	2	A_2, Ring sm*

No.	B	Name	Position		P	D	Cl	Notes
			in.	in.	°	in.		
49	35	δ Scorp.	L 4.1	B 2.0				i
50	36	13 Scorp.	R 1.1	B 2.3	134	0.8	6	nci, ws*n*
51	37	ϵ Scorp.	L 2.7	T 2.8	96	1.0	6	**n*, wm**s*
52	37	.....	L 1.3	B 3.8	104	0.7	3	0.7 x 0.5 in wm*f*
53	37	N.G.C. 6242	L 2.2	B 1.9	138	1.0	4	cl *nf*, ws*n* and *f*
54*	32	Π 4628	L 2.1	B 1.2	114	1.4?	4	ws*f*
55	38	ξ Oph.	L 2.9	T 1.0	162	0.2	2	39, 40
					160	0.6	6	
56	38	.....	R 2.7	T 1.6	88	1.1	3	A_3, 0.2 in b, ws*n*, 39
57*	38	θ Oph.	L 2.8	T 3.1	76	2.2	5, 6	39, 40, h8ws
58	38	Cl.	L 0.7	B 0.4	274?	0.9	4	h8
59	39	*	R 3.0	T 1.8	150	0.5	3	**fn*
60	39	.....	L 1.2	B 2.4	154	0.8	6	**pn*, wss, op*f*
61	41	N.G.C. 6494	L 0.4	B 1.5	208	0.8	4	cl *sf*, h8, 9, 42, 43, 44, 48
62	41	*o* Serp.	L 2.6	T 2.4	212	1.0	5	48, ws
63	41	*ν* Serp.	R 1.0	T 2.3	160	1.0	5	*c, ws *sf*, 0.2 in b
64	41	N.G.C. 6333	R 0.7	B 2.0	158	0.6	3, 4	cl*nf*, vD, pf*f*
65	41	ξ Serp.	L 3.2	T 4.0	201	2.0	5	nws
66*	42	58 Oph.	L 3.4	T 3.5	212	1.9	6	43, 44
67	45	λ Scorp.	R 1.9	B 0.7	250	2.0+	6	**p*, ws*f*, 46
68	45	N.G.C. 6405	R 2.6	B 3.4	.....		4?	nws, 46, 49, h8
69*	45	N.G.C. 6475	L 2.4	B 2.0	304	0.5	4?	nws, 46, 49
70	46	κ Scorp.	R 2.9	B 1.6	15	1.5	5, 6	**n*, ws*fs*, h8
71*	49		L 2.0	B 2.4	357	0.6	3?	d, *sc, h8
72	49		L 2.8	T 3.8	63	1.0	3?	d, dc, vo, 51
73*	51		L 1.6	T 0.4	53	1.7	?	irr, 54, 55
74	51	N.G.C. 6514	L 3.7	T 3.4	12	0.7	4	irr, 52, 54
75	53	67 Oph.	R 2.2	B 3.9	172	1.6	5	**n*, 1.6x0.9 in ws*n*, h9
76	53	66 Oph.	R 2.2	T 2.7			5	nci, **lf*, H1
77	53	68 Oph.	R 2.3	B 2.8		0.6	6	**nf*, h9 ws
78	54	N.G.C. 6611	L 2.4	T 0.4	69	1.2	4	cl*n*, ws*f*, 57, 58
79	54	N.G.C. 6618	L 2.0	T 1.9	75	1.5	4	cl*n*, ws*p*, 55
80*	56	N.G.C. 6656	L 1.9	T 2.7	287	1.9	4	cl *f*
81*	56		L 1.9	B 3.1		1.5		
82	56		L 2.2	B 3.6	262	1.0	3, 6	
83	56		L 1.7	B 2.8	264	0.7	3	
84*	56		L 2.2	B 2.2	200	1.3	3	
85	56		R 0:7	B 1.7	238	0.8	3	dc, ws*n*, 51
86	56	N.G.C. 6626	R 30.	T 3.2	266	0.8	4	cl*nf*, ws*f*, 51
87	57		R 3.1	B 3.1	129	1.0	3	A 1.0x0.6 in ws 58
88	57		R 2.9	B 1.9	210	0.8	4	ws *np*, 58
89*	59		L 2.5	B 0.7	117	1.2	4	vb*np*
90	59	N.G.C. 6907	L 0.3	T 1.6	71	1.2	4	cl*nf*, 60

No.	B	Name	Position in.		P °	D in.	Cl	Notes
91*	59		R 2.1	B 1.6	104	0.8	?	
92	60		R 3.6	T 2.7	111	0.7	3	pair *fn*
93	60		L 3.5	B 2.4	170	0.5	3	nci
94*	62		L 2.0	T 3.0	222	1.5	3	vm, 64, 65, 1.5x1.2 in
95	62		R 2.7	B 2.7	100	0.5	3	See B's note
96	62	*	L 3.5	B 3.6	232	0.3	5	nci, *c, 63, 64
97	62	N.G.C. 6494	L 3.0	B 3.4	75	0.7	4	cl, c, 63, 64, 65
98	66	18 Aquil.	L 2.5	B 1.7	61	1.0	5, 6*nc, 68	
99	66	111 Herc.	R 1.0	T 1.0	92	1.1	5, 6irr *lA_2	
100	66	ω' Aquil.	L 0.8	B 2.0	212	0.9	5, 6nws, ω^2 c?	
101*	66	28 Aquil.	L 0.5	B 2.5	282	0.8	5, 6*nc, 68	
102	66	*	L 0.9	B 4.2	335	0.7	3	**s*, 68
103	66		L 2.7	T 1.2		1.0	4	nci, bi*f*, 68
104	67		R 2.6	B 2.7	22?	1.4?	4	Large semi-ellipse, H1
105	67		L 2.9	T 1.9	25	0.7	3	
106	67		L 3.0	T 0.6		0.4	3	nci
107	67	*	R 1.0	T 2.6	242	0.4	2	
108	67	ι Aquil.	L 0.8	B 2.1	340	1.0	6	**fs*, b*f*, i
109	67	21 Aquil.	R 2.4	T 3.4	247	0.5	5, 6**ps*	
110*	69	α Aquil.	L 0.8	T 3.5	83	3.5?	6	*nc, H1 ws, 71
111	69		L 2.0	B 1.5	20	0.5	3	
112	69		R 1.4	B 2.6	269	0.9	3	nci, **ps* on edge
113	72	61 Sagit.	R 2.7	B 2.6	291	0.6	2	
114	73	N.G.C. 6830	R 2.0	T 1.8	12	1.0	4	cl, nc, ws*fs* to *n*
115*	74		R 2.9	B 3.2	41	5?	3	b 3.1 in, H2
116	74	N.G.C. 6910	L 1.0	T 1.5	182	0.9	4	cl, nc
117	74	N.G.C. 6819	R 0.6	T 1.7	50	0.5	4	cl *s*
118	74	N.G.C. 6913	L 0.9	T 3.0	297	0.4	4	cl *sp*, vex, 0.2 in, 76
119*	74		R 3.2	T 3.5			?	
120	75	N.G.C. 6940	L 1.0	T 3.0	308	1.0	4	
121	75	29 Vulp.	L 2.8	B 3.0	23	0.7	5, 6	
122	75	N.G.C. 6885	R 2.8	T 4.1	277	1.0	4	irr
123	75	41 Cyg.	L 1.7	T 1.7	31	0.3	6	*c, b 0.1 in *sf**, 79
124	79	48 Cyg.	R 2.0	B 2.4	36	0.5	5, 6**lsf*	
125*	76	γ Cyg.	L 2.8	B 3.4	294	1.5	6	
126*	76	*o* Cyg.	L 3.6	T 1.1	153	0.6	6**n*, 77	
127	76	N.G.C. 6866	R 1.9	T 2.4	100	1.0	4	cl*p*
128	76		L 1.3	T 2.7	160?	0.5	3	nci perhaps two
129*	76		R 3.1	T 2.0		0.9	3	ci
130*	77	α Cyg.	R 3.3	B 3.5	114	2.7	5, 6**f*	
131	77		R 3.1	T 3.0	104	1.2	4	
132*	77		R 3.5	T 3.3	41	0.5	4	

No.	B	Name	Position		P	D	Cl	Notes
			in.	in.	°	in.		
331	77		R 3.8	T 3.3	72	1.0	4	
134*	77		L 2.1	B 3.7	155	0.2	4	
135	77	57 Cyg.	L 2.5	B 3.0	317	0.8	5, 6	
136	77	56 Cyg.	L 2.8	B 2.8	342	0.6	5, 6	
137	77		L 2.6	B 2.7	352	1.6		A_2 with Nos. 135, 136
138	77		L 1.8	B 3.3		1.9	4	irr, A_2neb
139	77		L 1.1	B 4.5	48	1.8	4	irr, 78, H3
140	78	ν Cyg.	R 2.3	B 2.7	312	0.9	5	nws*np*
141	78	τ Cyg.	L 1.9	B 1.0	48	0.2	2	sm*n*
142	79	*	L 2.9	B 2.0	84	0.7	6	*c, vexc
143	79		L 3.7	B 2.8	91	0.8	3	0.8x0.3 in
144*	79		R 2.8	B 4.1		0.6	4	
145	81	π Cyg.	R 3.0	B 2.9		0.7	5	nci, irr, vbs*p*
146	81		R 2.9	B 2.4	340	1.0	3	1.0x0.8 in., H4, ws
147*	81	II 5146	L 2.3	B 1.6				H4
148	81	N.G.C. 7209	L 1.0	B 1.1	324	1.0	3, 4	cl *n* double? H4
149*	81		R 1.9	B 3.8	70	1.0	3,4	
150	82	N.G.C. 2840	L 3.3	B 2.6		0.3	2	nci, 84
151	82	9 Ceph.	R 2.9	T 1.1		0.3	2	83
152	82	λ Ceph.	L 1.7	T 2.8	218	0.8	2	nci, 84
153	82	ζ Ceph.	L 1.7	T 3.6	150	0.3	2	85, photographic?
154	82		L 0.8	T 3.2	202	0.7	3	A 0.7x0.5 in., *sc, 85
155*	85		R 3.2	T 2.5	60	1.2	4	cl *fn*e
156*	86		R 3.6	T 2.2	303	1.5	4	cl *fs*
157	86		L 1.7	T 2.0	301	1.6	4	nws
158	87	OΣ496	R 2.4	B 1.0	14	0.6	3	A 0.6x0.4 in, 86
159	87	β Cass.	L 1.7	B 1.4	345	1.3	6	89, 1
160	87	10 Cass.	L 2.1	T 2.6	156	0.3	2, 3	Anci, 89
161	89	N.G.C. 7789	R 3.1	B 1.8	38	0.8	4	cl *sp*c
162	16	ϵ Pers.	L 3.3	T 1.3	30	1.6	5	**sp*c, H7 bnc
163	16	ζ Pers.	R 2.9	B 1.9	357	1.5	5	*c, nci
164	16	o Pers.	R 1.6	T 2.1	42	1.1	5	**s*, nws, H7
165	16	ξ Pers.	L 3.1	T 4.0	11	0.9	5, 6	**s*, b, H7 two?
166*	16		R 1.4	T 2.8	84	0.3	6	
			HARVARD NORTHERN MILKY WAY					
167	3	δ Cygni	R 2.3	T 1.9	131	1.1	6	**s*, nws, i
168	4	α Ceph.	R 3.0	T 2.6	231	1.4	5, 6	m by stars
169	4	β Ceph.	L 2.5	T 1.4	260	1.1	5	irr, several?
170	5	ϕ And.	L 2.8	B 1.1			2, 6	irr
171	6		R 1.5	B 1.0	14	0.7	4	wm *n* to *p*
172	6	β Pers.	L 1.8	B 1.2	40	1.5	6	**s*, i
173	6	N.G.C. 1528	L 1.1	B 4.8	225	0.9	4	cl*nf*, ws*p*, double?

No.	B	Name	Position		P	D	Cl	Notes
			in.	in.	°	in.		
174	6	N.G.C. 1039	L 3.1	B 1.0	77	1.0	4	cl *sp*
175	7	11, 12 Cam.	R 0.8	T 1.8	135	0.3	2	6
176	6	N.G.C. 1444	L 2.1	B 4.5	106	0.4	4	cl*s*
177	7	δ Pers.	R 0.8	B 3.2	23	0.7	5, 6	**s*, 6
178*	7	β Aurig.	L 2.3	T 1.9			6?	**np*
179	8	β Tauri	R 2.7	B 3.8	40	1.5	6	**s*
180	9	134 Tauri	R 1.1	B 3.1			2, 6	nci, **s*, 9
181	8	16 Aurig.?	R 1.2	B 4.2		0.5	6	**fn*, ws*p*
182	9	5 Monoc.	L 0.5	B 2.0	60	1.0	4	ws *s*, others *n*

OTHER OBJECTS

183*	7	α Aurig.	L 3.4	T 3.3			2.6	
184*	7	θ Aurig.	L 0.7	T 2.7			4?	

HARVARD SOUTHERN MILKY WAY

185	1	α Canis	L 2.5	B 2.7	10	1.8	5, 6i	ws *n* and *np*
186	1	β Canis	L 2.8	B 1.4	358	1.0	6	nci, **ls*
187	1	N.G.C. 2506	L 0.9	T 1.6	270	0.5	4	cl *s*
188	1	N.G.C. 2548	L 2.2	T 0.6	292	0.6	2, 4	nci
189	1	N.G.C. 2287	L 1.7	B 2.3	0	0.4	4	cl *n*
190	1	α Can. Min.	R.1.4	T 1.0	155	2.0	5, 6	**n*, ws *s* to *p*
191*	1	N.G.C.2327 / 2343	L 3.2	B 4.4	270	1.1	2, 4i	
192	1	N.G.C. 2323	R 3.2	B 4.5	0	0.4	4	cl, nc
193	2	N.G.C. 2287	R 0.6	B 2.3		0.4	4	nci, cl, nc
194	3	N.G.C. 2546	R 1.8	B 3.8	40	0.7	4	cl *n*, vb*s*, 2
195*	3	α Pyxid.	R 1.4	T 3.5	158	0.7	2, 6	**sp*
196	3	N.G.C. 2547	L 2.6	B 3.0		0.2	2	nci
					334	0.8	4	ws*f* to *s*, cl, nc, l*n*
195	4	N.G.C. 2516	R 1.4	B 1.1	10	1.0	4	cl*p*
196	5	ε Cent.	L 1.6	T 2.6	2	1.4	4	wm **s*, 6
197*	5	α Crucis	R 3.0	B 4.4	64	2.4?	2, 6	
198*	5	β Crucis	R 3.6	T 4.6	177	1.5?	6	
199	5	β Cent.	L 1.3	B 4.6	219	1.2	5	**np*, vm *nf*, 6
200*	6	α Cent.	R 2.1	B 4.3	72	1.1	5	*c, ws*f*
201	6	ω Cent.	R 0.6	T 1.0	0	0.8	4?	
202	6		R 3.5	B 4.3	230	2.7	3	2.7x1.7 in. ws*f*, op*n*

ADDITIONAL NOTES

7. γ Cass., H5, shows a bright ring P 43° well seen *f*, making an object like Saturn.

12. Very large, extending from L 1.8 in., T 0.7 in. to L 0.4 in., T 2.1 in., ω (46) Cass. inside *np*. This star has perhaps a ring of its own; complicated structure, perhaps several rings. The great ellipse marked *np* by double curve of stars.

13. 31 Cass., traces of a much larger ring D 2.0 in., *n* of the star.

17. θ Persei, perhaps 2 rings, second *f*, producing by overlap irregular form and dark spot *s*, a little *f*.

39. γ Gem., very broad, 0.3 in. *p*, oval Absorption *n*, centre R 2.8 in. T 1.0 in. P 14°, D 0.7 in., H9 makes the absorption round the star larger.

40. Between N.G.C. 2245 and 15 Monoc., *n* part very dark, and marked by stars which seem to connect the two .28, 29 suggest one large ring with the two neb. on it on each side, partly lost under stars *s* and obscuring stars *n*. Between 13 and 15 Monoc. there are indications of an oval absorption beginning a little *f* 13, and ending *s* of 15. Another, very wide, above Neb., and extending to nearly ξ Gem. and on other side going out of plate at top R 3.5 in.; see 29 and H9.

42. α Gem., marked by long curve of small stars close above α Gem.; long, narrow, and ill-defined.

45. θ Scorp., broad ring, a second P 53°. Absorption very marked where the two meet; star itself seems to have absorption round it.

54. Broad *f* 0.2 in., very dark, possibly 53, 54 connected by one ring, P 144° D 1.5 in. on which Neb. is superimposed.

57. θ Oph. On all plates detail so complicated that main structure is lost. Better seen h 8. Inner edge *s* well marked by some 11 bright stars. The great, dark space *f* may be part of ring, the tilt being such that it cuts out Neb. *s* but is partly obliterated by the Neb. *n*, while the *p* part is somewhat buried beneath stars. The part of the ring nearest us would be about P 130° from θ where it is 1.0 in. broad and the outside diameter would be about 2.5 in. An oval absorption at R 2.2 in. B 3.2 in.; P 204°, 0.9 x 0.5 in., is partly filled in *n* in 39 and is well seen in 40.

66. 58 Oph. Complicated at *s* end by a large absorption ring, 0.3 in. broad, at *nf* and *sf* ends. A ring, *L* 3.2 in., T 2.6 in., P 211° D 0.9 in., well seen *nf*, further complicates matters.

69. **sf* with apparent absorption round it.

71. Perhaps part of a large ring.

73. Probably more than one ring; ends with black spot.

80. Apparently several rings, perhaps three, D 0.6 in., 1.4 in., 1.9 in., best seen *p*.

81. A curved line 2.2 in. long, a ring in line of sight? Also one above and two below.

84. Large and broad ring *p*ϕ Sagitt., very broad *sf* and well marked *np*. Nos. 82, 83, 84 all meet apparently and produce great obscuration at L 1.7 in., B 3.0 in.

89. Enclosing stars. Another seems to coalesce, L 3.6 in., B 0.6 in.

91. Dark line, a ring on edge? not conspicuous. Another *f*, P 104°, D 1.1 in.

94. Well seen from *nf* round to *s*, *f* complicated by stars and seeming to have second absorption oval, L 1.5 in., T 3.0 in.

101. 28 Aquil., No. 100,101 may be surrounded by large ellipse P 0° with 28 and ω^2 nearly at foci.

110. α Aquil. Best seen H1. Irregularities and holes *np* and *sf*.

115. About 3.1 in. broad at widest. Curved star streams south part, mentioned by Barnard, suggesting the real centre at R 1.6 in., B 2.4 in. The *s* part contracted and passing below the stars, and the *n* part emerging and crossed from *n* to *s* by streams of stars nearer to us. See H2, where the outline extends from L 1.1 in. to L 3.1 in.

119. Slightly curved absorption D 0.6 in., like a ring seen edgeways; trace of the rest of ring.

125. γ Cygni. All photos. with smaller lenses suggest strong elongated absorption round γ Cyg. P 200°, D 0.9 in., filled in mostly in Barnard's photo.

126. o Cygni. Perhaps Class 2; visible on all photos.

129. Several rings seem to intersect.

130. α Cygni. Band of stars from α Cygni to *p*, obscures ring. Best seen from *p* to *fn*, and round the star, passing below *R 2.9 in., B 3.0 in., cutting through No. 128.

132. This is formed by intersection of 131, 133, so that the *p* semi-ellipse belongs to 131 and the *f* to 133.

134. Typical ellipse with stars in centre; see pl 78. This is found on all photos. showing America Nebula.

144. Part of broad ellipse which may perhaps be traced on *s* side also.

147. See H4 R 1.6 in., B 2.9 in, where the neb. is at end of the most marked portion of an ellipse, well seen from *n* to *s*, but irregular *f*. On H4 it is 1.2 in. x 1.0 in. The bottom is at R 1.1 in. B 2.2 in., the top at R 1.3 in. B 3.2 in.

149. Oval Absorption with stars in centre. π' Cygni on edge *fn*.

155. N.G.C. 7380 on edge *fn*, below the ring is nearly 0.3 in. broad.

156. N.G.C. 7654 on edge *fs*. Broad ring enclosing stars, complicated structure. Cl. may be centre of another which is obvious *s* of Cl.

166. Small, sharply defined, very excentric, round a wide double.

178. Stars in circle *s*. Perhaps another L 2.0 T 2.4, P 219° D 2.0 in., star at *np* edge.

183. α Aurigae. This interesting example of Class 2 was first found on a photo. taken by Mr. Milburn with 95 min. exposure. It is also well shown on Mr. Richardson's photos. The P 180°, and it is 2° x 1½° in diameter. In photos. with large lenses it is lost in halation. H7 shows a large absorption, P 185° D 1.4 in., as measured on H7. The P.M. of Capella is approximately coincident with the major axis of the absorption.

184. θ Aurigae. This object was first noted on Mr. Milburn's plate and is well seen on Mr. Richardson's, and on all other plates, as well as H7. It is an ellipse of stars, P 255° D 1.75°, most of which are found in the B.D. There are traces of a second ellipse exterior to the first and marked by faint stars.

191. Traces of a much larger ring 2.0 in. in diameter.

195. α Pyxid. Another ring *p*, 237°, 0.6 in., wm by stars. The rings meet at α Pyxidis.

197, 198. The rings, apparently of great breadth probably emerge very steeply from the bed of stars and coincide, that of β being more sharply inclined than that of α, so that *s* of β and *fn* of α the absorption is more intense at the coincidence. The *s* part of the "coal sack" would then be due to the system of α, and the *n* part to α and β combined. The opposite ends of the rings in both cases are buried beneath the stratum of stars, that of α being less so than that of β.

200. Apparently 199 and 200 are connected by a semi ellipse. Of this ellipse α and β would be nearly in the foci.

Tow Law, Co., Durham,
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PERCIVAL LOWELL—HIS LIFE AND WORK*

By John A. Paterson

Nothing great was ever achieved without enthusiasm.—Emerson.

IN Percival Lowell were combined in a more than ordinary degree, scientific attainment and business ability. These are rarely united. The diagrams and figures illustrating some astronomical problem are not often associated with the dollar and cent columns of financial statements; in Dr. Lowell's case they were, for he was a master of mathematics, and also a leader in the business world. His tastes were both scholarly as an earnest and successful student, and also practical as a forceful and successful business man. He was a member of a brilliant family. He was born at Boston in 1855. His father Augustus Lowell was closely identified with the education and culture that made Boston famous. His mother was the daughter of Albert Lawrence, United States Minister to Great Britain in 1851. Two cities that are famous for textile manufactures bear the family names of Lawrence and Lowell.

The subject of this paper was a Harvard Graduate of 1876. He was a distinguished mathematician in these early days and the leading American mathematician of his day spoke of him as one of the most brilliant mathematicians of the Harvard men of that period. His truly receptive mind was largely benefitted by travels in Europe and the East. After seven years of close application to business he settled in Tokio, where he was appointed Counseller and Foreign Secretary to the Special Mission from Korea to the United States. He took charge of this first embassy from an eastern power in its American travel and on its return to Korea he became the guest of the Government. An account of his travels he published under the title of "Choson; the Land of the Morning Calm". Two weeks ago we heard a valuable

*A paper read before the Royal Astronomical Society of Canada, at Toronto (abridged).

address by Dr. Watson on "Astronomy in a Poet's Life"; our subject illustrates the converse of that, namely, "Poetry in an Astronomer's Life". For such works as "Choson", "The Soul of the Far East" and "Noto; an Unexplored Corner of Japan" were full of imagination and charm. In addition his fertile mind bore fruit in such volumes as "Mars" (1895), "The Solar System" (1903), "Mars and its Canals" (1906), "Mars as the Abode of Life" (1909), "The Evolution of Worlds" (1910); with many articles in various magazines and publications of learned societies including our own JOURNAL.

It was in 1877 that the Italian astronomer Schiaparelli, while engaged in a systematic study of the Planet Mars, was led to the discovery of a remarkable series of markings which he called *canali* a word incorrectly translated into "canals" and thus proving a source of confusion. Lowell followed these discoveries with deep interest, his imagination was fired, and with enthusiasm he extended those observations and ultimately based upon them his views of the habitability of Mars and hence of other planets In order more adequately to make observations and collect records he spent much time in seeking for the best possible site for an observatory. The great enemy to telescopic observations is unfelt swirling currents of air, which are more noticeable in great telescopes and render planetary detail confused. The effect may be compared to one holding up a page of fine writing and shaking it in all directions before an observer and then asking him what he sees. The best eyesight using the best instruments could make little advance in the knowledge of what was written on that page. Urania is secretive, and will not give up her secrets lightly, but demands from her worshippers ingenuity, perseverance, intuition and inventiveness before she will surrender any of her mysteries. When I speak of "swirling currents of air" I do not mean winds. These interfering currents cannot be felt by the ordinary senses, and may exist on a beautiful night beneath a cloudless sky and when the "floor of Heaven is thick inlaid with patines of bright gold". Some observatories are placed from a desire to be seen rather than to see, and high mountain tops are not conducive to good seeing. France and Algiers, the Mexican plateau, and the Andes of South America were in turn visited,

but after all a site at Flagstaff in North Arizona at a height of about 7,300 feet was ultimately selected, where the air was quiet and rarefied, and far from the smoke and dust and atmospheric tremor from street traffic of some populous centre. And under such circumstances the observing astronomer enjoys the best "seeing"—in a technical sense. And in these surroundings the great dome with its 24-inch refracting telescope was erected in 1894 and around that centre grew a considerable village with houses for the staff. Thereafter, under a separate dome, a 40-inch refracting telescope was installed, which however proved useless for the minute and accurate study of planetary detail. Here for many years Lowell with his staff created a mass of photographic and spectroscopic work which entitles him to be placed in the Pantheon of Astronomers. And from that observatory have gone forth a vast number of photographic transparencies of heavenly bodies and unique spectrograms, whereby the unlearned but appreciative people may derive some conception of the wonders of this universe wherein we live and move and have our being. Dr. Lowell had a noble ambition which found escape in a determination to have the astronomical work go on after his departure, and in order to accomplish that he chose as his Trustee a man of scholarship and kindred tastes, his cousin, Guy Lowell.

I had on the 4th July 1916, the pleasure of visiting this observatory and Mr. Slipher and Mr. Lampland, gave me, as an officer of this Society, a most cordial reception long to be remembered. Mr. Lowell himself was absent in Boston.

One of the chief purposes in the establishment of the Lowell Observatory was for the observation of the delicate markings on Mars. The facts are clear enough, the question is as to the proper conclusion to draw from these facts. There are two methods of reasoning; one by deduction from definitely ascertained premises; the other by induction, that is, to reach an inference from a consideration and analysis of some particular instance or instances. The inductive method is the correct interpretation of a series of observed facts with a view to understanding them and to relate them to the real cause or law. It was by this method that Neptune was discovered. It was found that the perturbations of the planet Uranus could not be explained by reference to the attractiveness

of known existing bodies, and thereupon theoretic calculations were made as to where was the unknown body which caused the swerving of Uranus from its proper orbit. In other words, given the disturbance, where was the disturber? As we know, the English astronomer Adams and the French astronomer Leverrier solved the problem, working independently, and Neptune was discovered, and introduced as a new but hitherto unknown member of the Solar family.

Now here are the facts as observed and recorded by the tireless workers at Flagstaff Observatory. Their discovery needed more than a good instrument and good eyesight. It needed brains working in the region of thought to understand and interpret what the physical eye saw.

1. Mars turns on its axis in 24 hours 37 minutes 22.65 seconds. This makes its day about forty minutes longer than ours.

2. The latest determination of the position of that axis, determined at this Observatory from all the best observations up to 1905, gave for its tilt to the plane of the planet's orbit, 24°. This determination has been incorporated in the *British Nautical Almanac*. Such a tilt causes seasons almost the counterpart of our own, except that orbital excentricity opportions them differently.

3. Its year consists of 687 of our days, 669 of its own.

4. It shows polar caps which melt in the Martian summer and form again in the Martian winter.

5. The making cap is of indefinite contour. It is a misty white, merging gradually into the surrounding land.

6. The melting cap, on the other hand, is bordered by a blue belt which retreats with the cap. This shows it to be the product of the disintegration of the cap. The fact excludes the possibility of its being formed of carbon dioxide, because that substance at pressure of one atmosphere or less, such as exist on Mars, passes at once from the solid to the gaseous state. We are left, therefore, with water as the only substance we know which could give rise to this phenomenon.

7. The great melting which the polar snows undergo shows their amount not to be considerable, in spite of their extent, and indicates the deposition to be scant.

8. The surface is divided into reddish ochre and blue green tracts, the reddish green being very much the more extensive. This has the look of our reddish deserts and from its general behaviour points to that as its constitution.

9. The blue-green areas, which used to be taken for water expanses, are now known not to be such because they are seamed with lines and spots permanent in place, which could not be the case were they lakes or seas.

10. They undergo a change with the Martian seasons, fading out during

the winter months and deepening in tint during the summer ones. They behave, in short, like vegetation, and all the evidence points to this as their character.

11. The fact that the caps melt and re-form shows, from what we have said above, the presence of water vapour in the Martian atmosphere.

12. This water vapour has registered itself on spectrograms taken by a member of the staff, Dr. Slipher. Spectra of the moon and Mars at the same altitude were recorded on the same plates and the density of the resulting water vapour band "a" proved more pronounced in the Martian spectra. Eight plates were used in all.

13. The fact of change upon the planet's surface confirms the presence of a Martian atmosphere.

14. The limb light seen around the edge of the disk affords testimony to the same.

15. The planet's low albedo proves the density of this atmosphere to be much less than our own.

16. These several facts all go to show that Mars possesses an atmosphere, which, since it contains water vapour, would, from the kinetic theory of gases also contain the heavier ones; nitrogen, oxygen and carbonic acid.

17. That the amount of the water vapour corresponds more to that over our deserts than anything else on earth.

18. That the only water on the planet exists in the atmosphere and in the polar snows. Mars, therefore, is a planet which is very badly off for water and can only get a surface distribution of it by the melting of the polar caps.

From the behaviour of the polar caps due to the fact that they can be nothing but hoar frost or snow, we have our first evidence that the temperature on Mars is by no means very low.

19. The fact that the snow caps disappear up to 87° of latitude, and sometimes further, shows that the temperature at times must be decidedly high.

20. The out-come of this investigation was to show that the mean temperature of Mars was probably about 8° centigrade. This is somewhat but not very much colder than the mean temperature of the Earth, which is usually taken as 15° centigrade.

21. The whole aspect of the disk bears out this conclusion. The seasons at which the melting of the polar caps begins, and the time at which it is brought to an end, at what corresponds to about the 20th August in our calendar,—this being the time at which the first new snow of the on-coming winter makes its appearance—all tend to show that the mean temperature must be just about what the theoretic puts it at.

22. The variations in temperature between summer and winter must, however, be very great, because of the thinness of the Martian air, and this also seems to be the case from the latitude, below 60°, to which the first snowfall reaches at the time of the year at which it does so.

23. The thin air, however, is no bar to vegetation, the climate of Mars being not that of a mountain peak but of a plateau, a very difficult matter.

From these two factors, sufficient water and enough warmth, we see that the

conditions on Mars are quite suited to habitability by organisms of some sort. This is one of the results which observations at the Lowell Observatory during the past fifteen years have established.

We now go on to the question of its present habitation by organic life, which is the one of most popular interest. Organic life needs water for its existence. This water we see exists on Mars, but in very scant amount, so that if life of any sort exists there it must be chiefly dependent upon the semi-annual unlocking of the polar snows for its supply, in asmuch as there are no surface bodies of it over the rest of the planet. Now, the last few years, beginning with Schiaparelli in 1877, and much extended since at Flagstaff have shown:

24. The surface of the planet to be very curiously meshed by a fine network of lines and spots.

25. The better the planet has been seen, the more this singular mesh discloses itself. It is very much as if a veil was drawn over the whole surface of Mars.

26. The lines of the network are each wonderfully straight, as if they had been laid down with the utmost regularity.

27. Their average width is apparently from ten to fifteen miles, certainly not more, and of the finer sort running down to a mile or two.

28. At the places where they meet are small, round, dark spots, which have been called oases by the writer.

29. Their look is geometrical to a degree, suggesting artificiality on its face.

30. Six months after the phenomenon thus disclosed at one cap, a regular wave proceeds from the other cap down the disk in the opposite direction. Thus in every Martian year two waves of darkening affect the canal system alternately from one cap and then the other, this rythmic oscillation in appearance being exactly timed to the planet's seasons.

31. The oases undergo a similar regular transformation. From the merest pinpoints they develop into quite sizable round spots, and then in due season fade out again to what they were before.

I said, "Here are the facts"; now I add, "Here are the conclusions". If one considers first the appearance of this network of lines and spots, and then its regular behaviour, he will note that its geometrism precludes its causation on such a scale by any natural process and, on the other hand, that such is precisely the aspect which an artificial irrigating system, dependent upon the melting of the polar snows, would assume. Since water is only to be had at the time it is there unlocked, and since for any organic life it must be got, it would be by tapping the distinguishing cap, and only so, that it could be obtained. If Mars be inhabited, therefore, it is precisely such a curious system we should expect to see, and only by such explanation does it seem possible to account for the facts.

These lines are the so-called canals of Mars. It is not supposed that what we see is the conduct itself. On the contrary, the behaviour of these lines indicates that what we are looking at is vegetation. Now, vegetation can only be induced by a water supply. What we see resembles the yearly inundation of the Nile, of which to a spectator in space the river itself might be too narrow to be seen, and only the verdured country on its banks be visible. This is what we suppose to be the case with Mars. However, the water be conducted whether in covered conduits, which seems probable, or not, science is not able to state, but the effects of it are so palpable and so exactly in accord with what such a system of irrigation would show, that we are compelled to believe that such is indeed its *vera causa*. For all of this I am much indebted to the kindness of the Flagstaff astronomers.

The reasoning from these premises is short and not complicated. The existence of vegetation on the planet is the only rational explanation of the dark markings there considered not only from their appearance but by the additional fact of the changes they undergo at successive seasons of the Maritian year. The presence of a *flora* is ground for suspecting a *fauna*. What would be the use of vegetation unless to support animal life,—and if animals there, it would be strange if there was not also intelligent animal life, in other words creatures that would bear the same relation to Mars as human beings here bear to our earth. Furthermore the water originating at the pole moves down to the equator as the season advances. It does this independent of gravity, and the inference is inevitable that it is artificially helped to its end. Moreover it progresses uniformly, not like rushing natural rivers but in some way its transference is assisted. How and by what means?

Lowell does not hesitate to give his explanation and state conclusions. In his book "Mars as the abode of Life" he says:

> We have indulged i n no speculation. We have carefully considered the circumstantial evidence in the case and we have found that it points to intelligence, acting on that other globe and is incompatible with anything else. We are justified in believing that we have unearthed the cause and our conclusion is this: That we have in these strange features which the telescope reveals to us witness that life, and life of no mean order at present inhabits the planet. Thus not only do the observations we have scanned lead us to the conclusion

that Mars at this moment is inhabited, but they land us at the further one that these denizens are of an order whose acquaintance is worth the making. More important to us is the fact that they exist made all the more interesting by their precedence of us in the path of evolution. . . . Whether we shall come to converse with them in any more instant way is a question upon which Science (at present) has no data to decide.

This last observation made by such a man and of such scientific attainments relieves him from a charge often stupidly hurled at him that he was obsessed with Mars without rhyme or reason and ready to give a loose rein to his imagination and even seek to rival Dean Swift in his remarkable classic "Gulliver's Travels".

But notwithstanding the reasoning endorsed by Dr. Lowell, not only as to the habitability but even to the actual habitation, we must make an approach to Mars with a feeling of hesitancy, knowing how easily we turn from the firm ground of scientific investigation to the slippery path of romantic story. The *Edinburgh Review* of October, 1896, tells this story. A lady of the inanely inquisitive kind, having met an eminent astronomer, implored permission to ask him one question. "Certainly, madam", he replied, "if it is not about Mars". It was about Mars. The popular humor delights in philosophy decked with the charm of conjecture. Anything which is conceivable may be interesting, but science is founded upon the rock of evidence. Far better is it to have many observations and few theories than to have few observations and many theories. Such extraordinary conclusions have been enunciated that one is apt to treat Mars and his observers too lightly. And though much has been written and spoken to gratify the popular humor, I know that astonomers have recorded many things about Mars that lie on the very bed rock of truth. The first hint that the world had of the existence of the so-called canals, in Mars was given by Schiaparelli in 1877. The world, however, was not prepared for the revelation, and while others doubted, he went on from discovery to discovery. In 1879 the "canali" as he called them, showed straighter and narrower than they had in 1877, this, not in consequence of any change in them, but from his own improved faculty of detection, for what the eye has once seen it can always see better a second time. Lastly, towards the end of the year, he observed one evening what struck even him as a startling phenomenon, the twinning

of one of the canals, two parallel canals suddenly showed where but a single one had showed before. The paralleling was so perfect that he suspected an optical illusion. He could, however, discover none by changing his telescope or eye pieces. The phenomenon apparently was real. At the next opposition he looked to see if by chance he should mark a repetition of the strange event and then he saw twenty of them double. This capped the climax of his own wonderment and it is needless to add to other people's incredulity, for nobody else had yet succeeded in seeing the "canals" at all, let alone seeing them double. For nine years he laboured alone, having his visions all to himself. It was not till 1886 that any one but he saw the canals. In April of that year Perrotin, of Nice, first did so, when the great Nice telescope of 29 inches aperture was set up. But it was some time before, even with this glass, they could be discovered. But suddenly Perrotin discovered one of them called the *Phison*. His assistant, M. Thollon, saw it immediately afterwards. Afterwards they managed to make out several others, some single, some double, substantially as Schiaparelli had drawn them. Since then other observers have continued to detect them, the number increasing every opposition.

"That Mars seems to be inhabited", says Dr. Lowell, "is not the last but the first word on the subject. We must look at things now from a new standpoint and take a broad sweep, not take merely a local view. By a local view I mean a terrestrial view. The human race with all its proud attributes may after all be but a link in the chain". I like Tennyson's philosophy,—hearken to it:

> "This truth within my mind rehearse
> That in a boundless universe
> Is boundless better, boundless worse
> Think you this mould of hopes and fears
> Could find us statlier than his peers
> In yonder hundred million spheres?"

But let us halt, let us remember the warning that "the assertion which outstrips evidence is not only a blunder but a crime". Bacon in his essay on "Truth" truly said, "the mixture of a lie doth ever add pleasure", by which he meant not a lie in malice,

but any bold statement that was fleeter of foot than evidence. Rigid demonstration is unpopular, but any astronomer of reputation and ready wit can fill a lecture hall if he proposes to discuss the altitude of the Martian inhabitants, or if he will tell us how to construct some mighty triangle or pentagon on the desert of Sahara, light it up with myriads of electric lights, then watch for results from our neighbour Mars.

It is a profound mistake to think that everything has been discovered. We may as well think that our horizon is the boundary of the world. As time moves on, and thinkers continue to think, and knowledge grows from more to more, what was the horizon of yesterday is not our horizon to-day, and the horizon of to-morrow is yet different from either, and so the restless Ocean of Time casts upon the shore sometimes a worthless weed and sometimes a precious pearl, and at other times some mysterious waif which may prove to be an unpolished gem or only rough rubbish.

It grew late and dark with Lowell on this side of the impenetrable veil between this life and the great beyond on the 12th of November 1916, and a golden key opened for him the palaces of Eternity. It was then that Death, the black camel, knelt at his gate,—I use a beautiful Oriental imagery. No storied urn nor marble bust can call the fleeting breath back to its mansion. God buries his workers, but not their work; it goes on from more to more, and our knowledge is the amassed thought and experience of innumerable minds. And of these innumerable minds Lowell filled a place more than important.

MEETINGS OF THE SOCIETY

AT LONDON

May 7, 1922.—An observation meeting was held at the Normal School on Friday, May 7th. During the early part of the evening the presence of clouds hindered observations but later on the sky cleared and a very successful meeting was held. Four telescopes were secured for the occasion and observations were made of the rings of Saturn, the moons of Jupiter, Venus, the Moon, and some double stars. This was the closing meeting for the season.

E. T. WHITE, *Secretary.*

AT TORONTO

April 18, 1922.—The president occupied the chair. Mrs. and Mr. George Service, 72 Briar Hill Ave., Toronto, and Mr. S. L. Neave, 1208 W. Clark St., Urbana, Ill., U.S.A., were elected members.

Prof. L. B. Stewart, D.T.S., of the University, gave an address upon the subject of "Geodetic Reconnaissance". The lecturer gave a short historical account of geodetic surveying. The first attempt since the Middle Ages, to determine the size of the earth was made by Norman, an Englishman, who used chains in measuring distances. In 1615, the method of triangulation was devised, which method, although greatly refined, is used to-day. The expeditions of the French Academy of Science to Peru and Lapland, in the early eighteenth century, to determine the shape of the earth were described; the triangulations being shown on the screen.

Precise instruments and the application of the method of Least Squares to the calculations, permit great accuracy to be obtained in modern surveys. It is now customary to use a chain of quadrilaterals or central polygons instead of the primate triangles, so that, by measuring all the angles and the sides a great many conditions are created which must be satisfied, and the result thus obtained is very accurate. Moreover each angle is read as many as 96 times, to the individual second. As an example, the lecturer stated that in the United States Survey of the 39th parallel, the longest chain of triangulation in existence, the estimated error is only 26 metres in 2,600 miles.

The general field work of a survey was discussed at some length; slides being shown illustrating the instruments and beacon lights used and also the method of constructing the observing towers. The lecturer described several interesting events he experienced while on the surveys of the Gulf of St. Lawrence and the Maritime Provinces.

May 2, 1922.—The president occupied the chair. The following were elected members: Rev. Euclide Gervais, S.J., St. Boniface College, St. Boniface, Manitoba; R. J. McLellan, Edmonton, Alberta; James Sharp, Sudbury, Ontario; Miss Margaret Evelyn Watt, 26 St. Joseph St., Toronto, Ontario; H. S. Robertson, M.A., Stratford, Ontario; Prof. K. P. Johnston, M.A., Queen's University, Kingston, Ontario; Robert A. Kennedy, Nairn Centre, Ontario.

Dr. A. D. Watson, a past-president of the Society, read a paper upon "The Norse Discovery of America". The lecturer stated that previous to the twelfth century, the legendary exploits of the Vikings were preserved in songs and stories called "sagas", which were carefully memorized and handed down from generation to generation. They were the traditional accounts of historical events, and many of them related to the discovery and landing on the American continent about the year 1000 A.D. During the twelfth century the sagas were written. The most authoritative account of the discovery of America is found in the Icelandic manuscript known as the Flatey Book, written about 1387, and now preserved in the Royal Library at Copenhagen. A book containing portions of the Icelandic manuscript with the Danish and English translations was exhibited, and, after the lecture, examined by the members.

Frequently quoting from the interesting manuscript the lecturer described the travels of Eric the Red, who being exiled from his home on account of manslaughter, went to Iceland about 970 A.D. He discovered Greenland, giving it the name to attract colonizers. The continent was first seen by Bjarne Herjulfson and his crew who were driven out of their course by a storm. They did not land however and on their return to Greenland, Leif the son of Eric, organized a party of 35 men who set out to seek the new land. They found the continent and spent the winter there, living in tents. The saga describes the characteristics of the country, the finding of the wineberries which gave the name of Vineland to the country, the subsequent voyages of the Norsemen and their ultimate withdrawal due to the hostilities of the natives.

The question of the latutude of Vineland has not been finally settled. It is stated in the saga that on the shortest day of the year the sun rose before 9 a.m., and set after 3 p.m. From this information, *i.e.*, the declination of the sun and the hour angle at sunrise, a simple computation determines the latitude to be 57 or 58 degrees north, corresponding to middle Labrador. The lecturer, from the other evidence of the story believes that Vineland must have been as far south as Newfoundland or even Nova Scotia. The vicinity of Boston has frequently been claimed as the spot where the Norsemen landed.

The General Secretary, Mr. A. F. Hunter, spoke about the recent finding of Runic stones referring to Vineland, the following being a summary of his remarks:

In connection with the Norse discovery of America certain events and findings in recent years have an intimate bearing upon the subject. Twenty-four years ago a farmer named Olaf Ohman in the State of Minnesota found a stone inscribed with runes. The discovery came to the attention of various men reputed to be learned in such matters, but the inscription came at the time to be pronounced a forgery and the stone was returned to Mr. Ohman, who made of it a

doorstep for his granary. In this menial service it lay for the first ten years of its career, discredited and almost forgotten, until a man at work on material for history chanced to be in the vicinity of Kensington, Minn., where the find had been made and he obtained it. The Minnesota Historical Society then took a part in the investigation of the relic, and appointed a committee of five members, headed by the late Prof. N. H. Winchell, the geologist. This committee took a favourable view of the authenticity of the Kensington Rune stone, and in recent years it has been regarded with more credit. The translation recorded that eight Goths and twenty-two Norsemen on an exploration journey from Vinland at the sea, which was fourteen days' journey distant, had camped near where the stone was left. While part of them were out on a fishing trip ten of the party at home were massacred, in the year 1362.

The final Norse voyage to America was made in 1347, and the date recorded on the stone, viz., 1362, falling fifteen years later, adds some mystery, yet there is nothing improbable in the circumstance, as other voyages may never have been recorded, or a colony planted by the Norsemen may have survived for many years afterward. A runic stone found in Baffin Land, and recording the death of some ancient Norse mariner, has been preserved in the Museum at Copenhagen for many years.

In 1917, Mr. H. P. Steensby, a Danish scholar, published in English a study of the literature relating to the Vinland question, under the title, "The Norsemen's Route from Greenland to Wineland". Mr. Steensby made an attempt in that publication to settle the position of Vinland, and in doing so relies chiefly on the saga of Eric the Red. Following the track of the voyagers, as described in the saga, he identifies Helluland as Labrador, Markland as Newfoundland but discards the identification of Vinland with Nova Scotia. He points out that, as the voyagers left Markland behind, "the country lay to starboard", that is, to the right hand, and so he concludes that the final destination reached, according to the saga, must have been Montmagny or St. Thomas on the south side of the St. Lawrence, below Quebec city, because the voyagers landed on the "larboard" side. There is difficulty in these attempts to identify the places named in the sagas owing to the great vagueness of the accounts left by the illiterate Norse discoverers. Another difficulty lies in the fact that the geographical conditions on the North American coast nine hundred years ago were different from those of to-day, when the waterline is lower and the climate more severe. Mr. Steensby assumes that the conditions were the same, but this is perhaps open to some doubt.

May 16, 1922.—Mr. James Holcroft, 243 University Ave., Toronto, Ontario, was elected a member.

Prof. C. A. Chant drew the orbits of Mercury, Venus and the Earth upon the board, showing the relative positions of these planets at the present time. He explained how it was possible to see Mercury for a period of about ten days when at or near its greatest elongation from the sun, which takes place on May 23rd. Some of the members reported that they had seen the planet this week.

On motion of Prof. Chant, seconded by A. F. Hunter, it was resolved that

a vote of condolence be sent to Mr. M. F. Miller to the effect that the Society has learned with deep regret of the death of his wife, and wish to tender him their sympathy in his loss.

The president then called upon Mr. J. R. Collins to read a paper entitled "Astronomy in Bermuda", which was communicated by the Rev. Dr. D. B. Marsh, of Hamilton, Bermuda. The paper described the observations of Dr. Marsh and Rev. E. D. Robinson, with their 3-inch equatorially mounted telescopes. As the climate is ideal the definition is exceptionally good, but on account of the coral nature of the island, the vibrations of traffic interferes with photographic work. As a sample of the pictures obtained, six slides were exhibited, one of the sun showing two fine groups of spots, two of the moon showing considerable detail, and three of the instruments and observers.

Dr. Marsh has mounted his transit upon the roof of his house and takes regular observations for time which he gives out to the island, the master clock being kept in the church.

In addition to giving courses on popular lectures he allows the public to use his telescope twice a week, so that interest in astronomy is becoming very general and many take advantage of the opportunity to see the stars and planets.

After the paper, Mr. H. S. Crewe, of Toronto, who has recently returned from Bermuda, spoke very interestingly of the work of Dr. Marsh whose time service is greatly appreciated by the city of Hamilton, Bermuda.

May 30, 1922.—The final meeting of the Society for the Spring term of 1922, was held on May 30th. The two telescopes of the Department of Astronomy were mounted on the campus of the University, and a pleasant evening was spent observing the Moon, Venus, Jupiter, Saturn and a few double stars. The six inch telescope of the Meteorological Service was also at the disposal of the members, under the direction of the president. The attendance at the two places totalled two hundred.

J. A. PEARCE, *Recorder.*

NOTES FROM THE METEOROLOGICAL SERVICE, APRIL, 1922

Temperature

The temperature was below the average in British Columbia and in Alberta, also in the extreme southwestern portion of Saskatchewan as well as in Prince Edward Island and Cape Breton and very locally in the Lake Superior district; elsewhere in the Dominion it was generally above the average. The positive and negative departures varied from one to three degrees. The chief positive departures occurred in Manitoba and in the southern portion of the peninsula of Ontario.

Precipitation

The precipitation was below the average in Vancouver Island and over the Lower Mainland of British Columbia and above in the interior districts. In Alberta it was above the average; in Saskatchewan below locally in the western part and above elsewhere; in Manitoba it was much below the normal; in Ontario it was below in the Lake Superior district and considerably above in nearly all portions of the remainder of the province; in Quebec it was well above the average except in a few points where there was a deficit; in the Maritime Provinces it was everywhere below the average.

SEISMOLOGICAL NOTES FOR APRIL.

There was increased seismic activity from last month. Victoria recorded 14 quakes and Toronto 10. The most important were on the 2nd, 5th, 8th and 25th.

On the 2nd, trace amplitude at Victoria was 2.25 mm. and at Toronto 2 mm.

On the 5th, Victoria shows an amplitude of 4.3 mm. and Toronto 2.2 mm. This quake was 6860 km. from Victoria and all the phases at the station were beautifully defined. The S waves came in rather abruptly at 10h 30m 56s G.M.T., and from 10h 45m to 10h 49m, gradual, increasing waves of disturbance were recorded

and then became gradually smaller. The period was about 18 seconds.

On the 8th, Victoria trace amplitude shows 8 mm. and Toronto 9 mm. Disturbance of quake from Toronto, 4030 km. The P waves of this earthquake were recorded at 20h 54m 36s in Toronto and at 20h 57m 50s in Victoria. The S waves at Toronto had an amplitude of 2 mm. the L waves being somewhat difficult to interpret.

On the 25th, Toronto shows an amplitude of 1.2 mm. and Victoria 0.7 mm. The P and S waves of this earthquake were not recorded at either station. Victoria gives time for L as 21h 41m 14s, and Toronto, 21h 49m 42s and 22h 21m 0s. J. Y.

TEMPERATURES FOR MONTH OF APRIL 1922

STATIONS	Highest	Lowest
Yukon		
Dawson	52	2
British Columbia		
Atlin	52	16
Agassiz	67	32
Barkerville	58	6
Kamloops	79	25
New Westminster	64	33
Prince Rupert	56	29
Vancouver	62	22
Victoria	60	35
West Provinces		
Battleford	77	11
Calgary	72	10
Edmonton	72	10
Medicine Hat	68	21
Minnedosa	76	8
Moosejaw	78	14
Oakbank	71	15
Portage la Prairie	75	15
Prince Albert	74	13
Qu'Appelle	76	11
Regina	75	5
Saskatoon	74	13
Souris	77	14
Swift Current	74	16
Winnipeg	72	16
Ontario		
Agincourt	75	23
Oak Ridges	70	20
Bancroft	67	15
Barrie	71	20
Beatrice	64	13
Bloomfield	70	23
Brantford	77	23
Chapleau	55	0
Chatham	79	28
Clinton	71	21
Collingwood	75	20
Cottam	..	..
Georgetown	73	21
Goderich	69	17
Grimsby	74	26
Guelph	74	20
Ontario—cont.		
Haliburton	67	13
Huntsville	66	10
Kenora	68	12
Kinmount	70	19
Kingston	74	25
Kitchener	77	21
London	79	22
Lucknow	68	18
North Gower	..	..
Oshawa	..	..
Ottawa	74	24
Paris	79	22
Parry Sound	62	18
Peterborough	74	22
Port Arthur	66	14
Port Dover	70	24
Port Stanley	70	22
Queensborough	71	20
Ronville	64	15
Southampton	71	24
Stonecliffe	..	..
Stoney Creek	78	25
Toronto	78	25
Uxbridge	..	..
Wallaceburg	..	..
Welland	72	24
White River	60	8
Quebec		
Brome	..	..
Father Point	68	18
Montreal	66	24
Quebec	67	25
Sherbrooke	67	23
Maritime Provinces		
Charlottetown	56	22
Chatham	64	22
Fredericton	66	23
Halifax	62	24
Moncton	63	20
St. John	60	27
Sussex	63	22
Sydney	58	22
Yarmouth	56	24

ASTRONOMICAL NOTES

BIOGRAPHIES OF ASTRONOMERS

Silhouettes d'astronomes contemporains, by A. Collard (*Ciel et Terre*, February 1922).

A new and interesting feature found in the Bulletins of the Belgian Society of Astronomy is the description of the lives and works of astronomers who died since 1910.

In the February number, data is found concerning the life of the French astronomer Auguste Charlois (1864-1910). Charlois was particularly remarkable in that he discovered 112 small planets of which 75 by photography. He concerned himself greatly with the computation of their orbits. He was assassinated on March 26th, 1910.

F. H.

OBSERVATIONS OF VARIABLE STARS

Annales de l'Observatoire de Leyde. A valuable piece of work has been published by W. J. Luyten in these annals.

From September 1915 until October 1919, the Dutch astronomer made 13,500 observations on variable stars as follows: Algolids and Cepheids, 3,800 observations for 17 stars. Irregular variables, 2,700 observations for 20 stars. Long period variables, 7,000 observations for 151 stars.

In the last chapter of his work, the author studies the important question of a change of period in variable stars. Besides his own observations he used observations published by Harvard College and by the Astronomische Gesellschaft and found that a change of period is certain for R Aquilae, R Ursae Majoris and T Geminorum.

Contrary to the opinion of Professor Turner of Oxford who believes that changes of period occur suddenly, Mr. Luyten thinks that it is a slow and continuous variation.

F. H.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

OCULAR DEMONSTRATION

An enlightened father, desirous of introducing his two little sons to the movements of the heavenly bodies, obtained a model exhibiting the motions of the sun, earth and moon relative to each other. The children observed the model with great interest as it was shown to them or as they operated it themselves. Some time later, one of them, six years old, informed a little playmate that he was sure the earth went around the sun as he had *seen it going*. .

Very recently some visitors were being shown the planet Saturn through a small telescope. As is well known, the rings in 1921 were turned edgeways to the earth and could not be seen at all. They are still very narrow, though they can be seen without difficulty. A lady on seeing the planet remarked, "Oh! Saturn has an axis!"

PERSONAL MENTION

During the month of May the University of Padua, in Italy, celebrated the 700th anniversary of its foundation; and the Royal Astronomical Society of Canada was represented at the ceremonies by Dr. Otto Klotz, Director of the Dominion Observatory and Dr. E. Deville, the Surveyor General, both of whom are accredited Canadian delegates to the meeting of the International Astronomical Union in Rome.

Mr. J. A. Pearce, M.A., who has been a very competent assistant in the department of Astronomy in the University of Toronto for the last two years, has accepted a fellowship in the Lick Ob-

servatory, Mount Hamilton, Cal., and will begin his duties on July 1. The good wishes of Mr. Pearce's numerous friends go with him in his new work.

A NEW POEM BY DR. WATSON

Readers of the JOURNAL will be interested to learn that Dr. Albert D. Watson, a former president of the Society, has published a poem entitled "The Dream of God". It is written in quatrains and explains the philosophy of the Bahai movement, which is based upon the teachings of Baha U'llah and Abdul Baha. I take the liberty of quoting the sonnet which introduces Part 4, and also the last stanza of the poem:

The moon is waning and will soon be set.
With folded tents, the starry caravan
Melts into light. Above each lowly khan,
The palms stand out in lordly silhouette
Against the brighter dawn; but even yet,
Some souls are sleeping; since the world began
With music of the morning stars hath man
Been eating lotus-leaves and doth forget.

A bird trills out his carol to the skies,
A song of life, for this is what he saith:
I sing once more the phoenix-dirge, of death
Love-conquered. It is death alone that dies.
Now over plain and city, sea and sod,
The new-earth bells chime out the dream of God.

. . . . . .

Now all our fetters—warnings from the past,
With forward urging, far away we cast;
We burn our ships and climb along the stars,
Facing our steadfast future calm and vast.

C. A. C.

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THE FESTIVAL OF THE DEAD, by R. G. HALIBURTON.

This very scarce pamphlet, printed privately in 1863, was republished in the JOURNAL of the R.A.S.C. and can be obtained in a book of 126 pages. The work discusses the Year of the Pleiades and various questions relating to old calendars. It is of special interest to astronomers, anthropologists and ethnologists. Price $1.00, post-paid.

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